AIRS Calibration Update

Steve Broberg

AIRS Science Team Meeting
April 5th, 2019

AIRS Cal Team:
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Jet Propulsion Laboratory, California Institute of Technology
*UMBC **Raytheon

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State of the L1B

- It hasn't changed - it is called "v5", but the calibration core, its coefficients, have not changed since launch.

- Same calibration across 5 presidential terms (17 years and counting)
  - At least one more to go - the A train exit and extended mission starts in 2022.

- Characteristics
  - One set of static coefficients for each channel
  - Good to about .1 to .2 K absolute for typical scenes
  - Each of the 2378 channels is an "independent" radiometer – some behave better than others

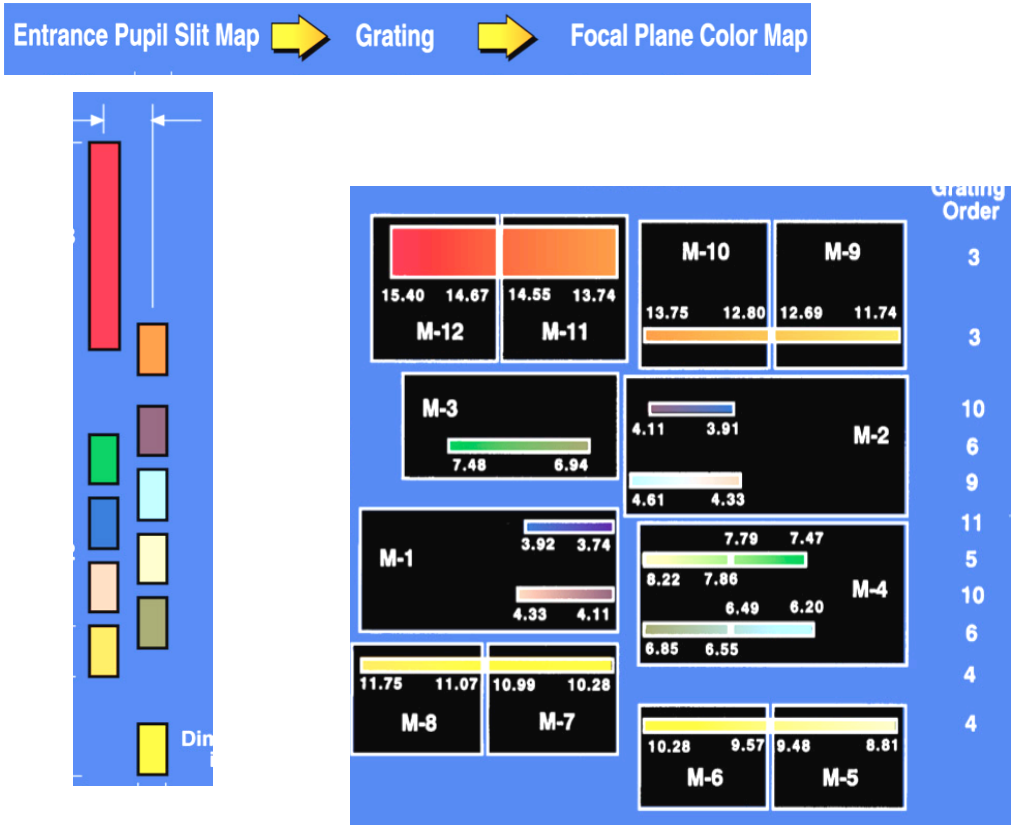
- Why consider a change now?
  - Absolute cal is worse for extreme cold scenes
  - Time dependent changes have been observed
  - New coefficients have reduced uncertainty estimates

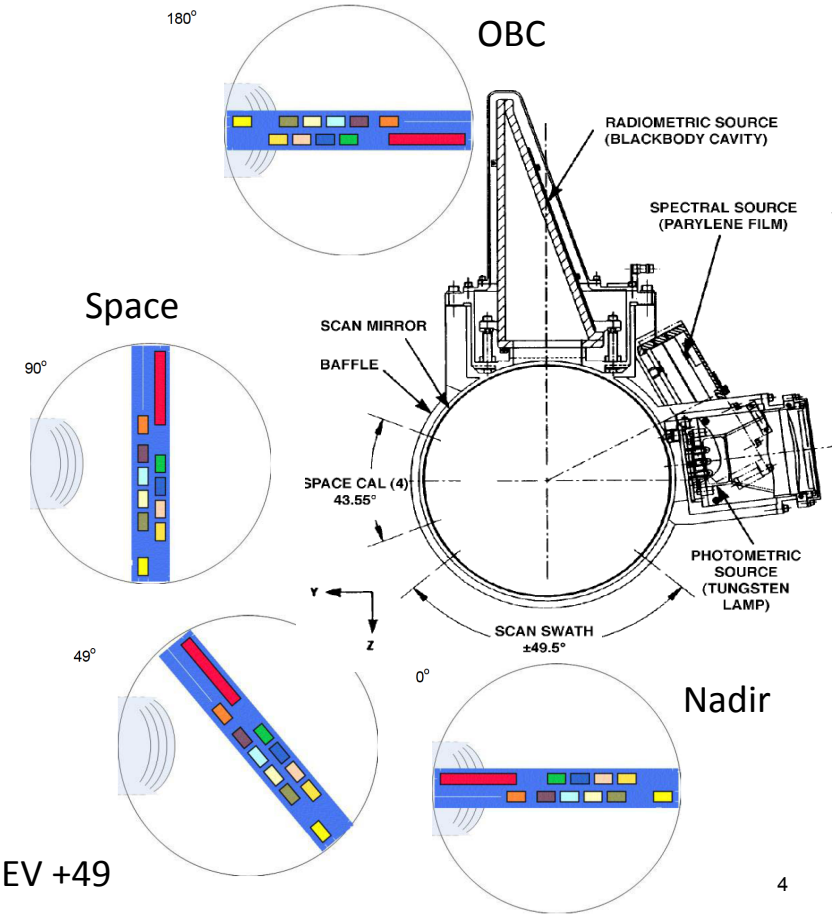
- Some issues are best addressed in L1B, some in the L1C product, some in between

Session Talks

- AIRS Frequency Drift and Doppler Correction – Strow
- Trends in the L1B V5 – Aumann
- Possible Shortwave Contamination in AIRS due to Near Field Response – Wilson
- The L1B v7 Lien List – Aumann
- AIRS Calibration Updates for Climate Benchmarking - Pagano

A Reminder of What We are Calibrating

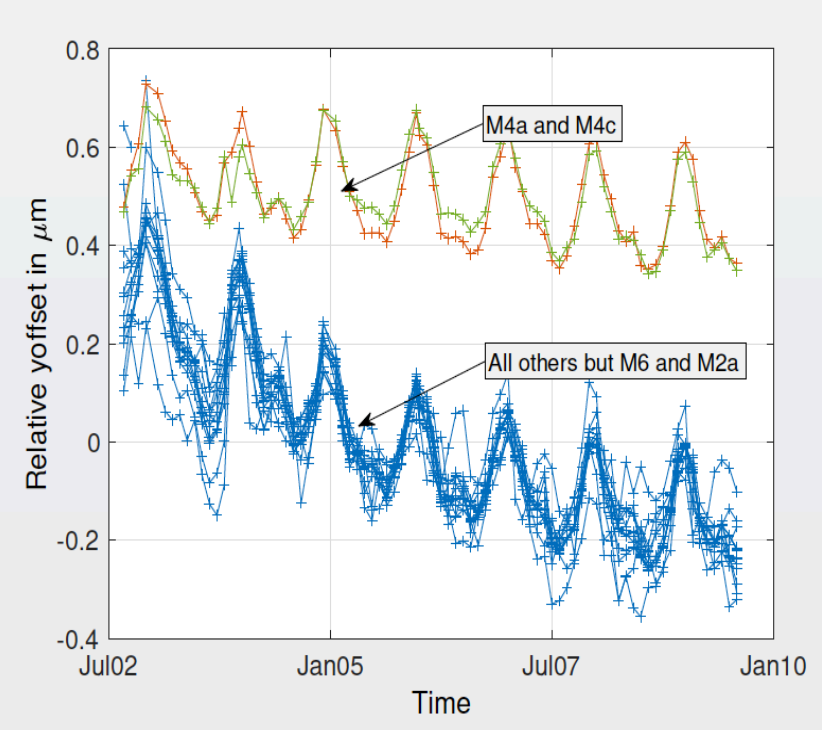




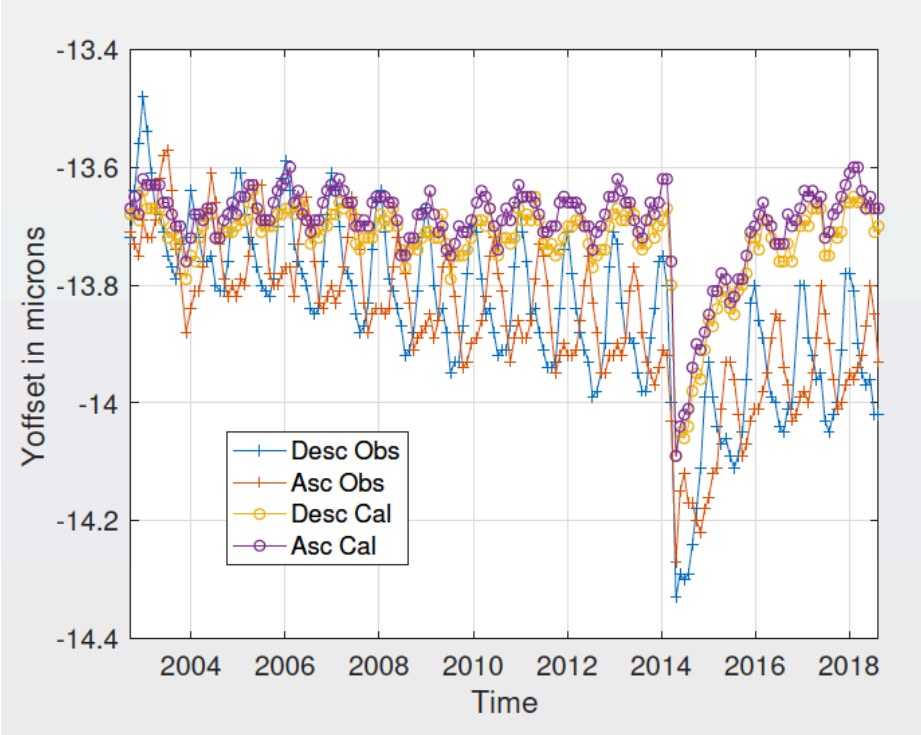
11 Entrance Filters x 12 modules x 2378 detectors

EV +49

Module Dependent Spectral Trends (Strow)



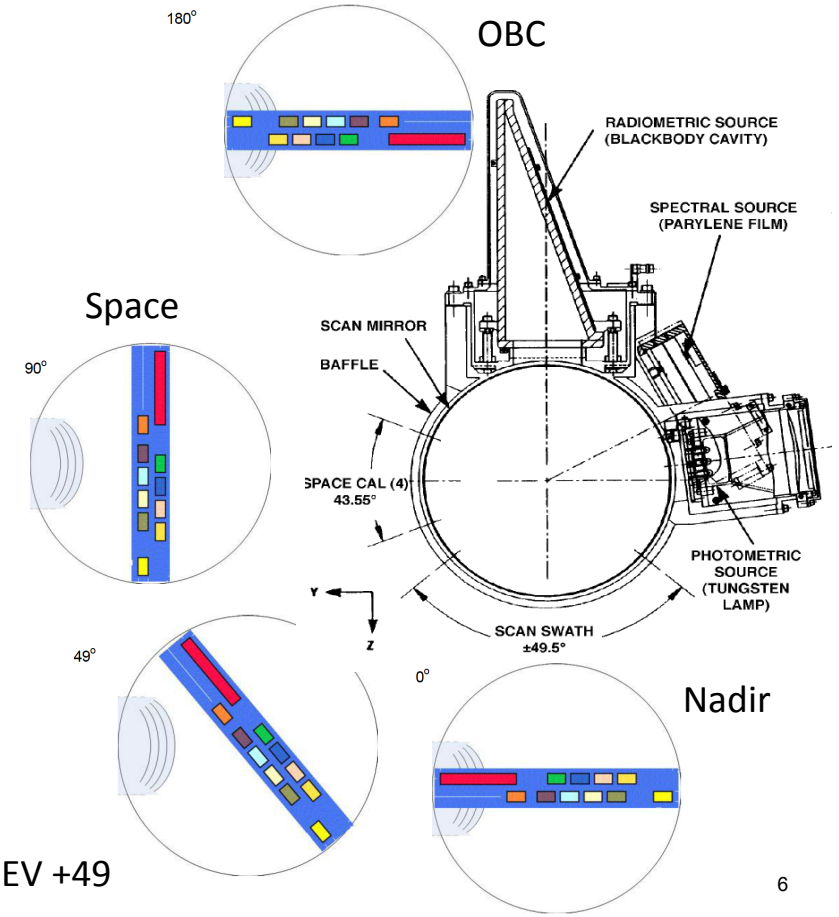
Modules M-04a and M-04c are experiencing different spectral shifts than all other modules – this was not expected



Modules M-04a (and c) also shows an unusual offset and drift the 2014 cooler anomaly and FPA warm up – also not expected

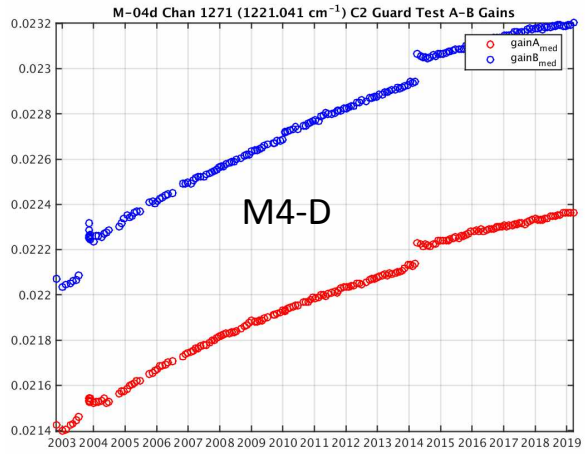
Why would M4 A and C move similarly?

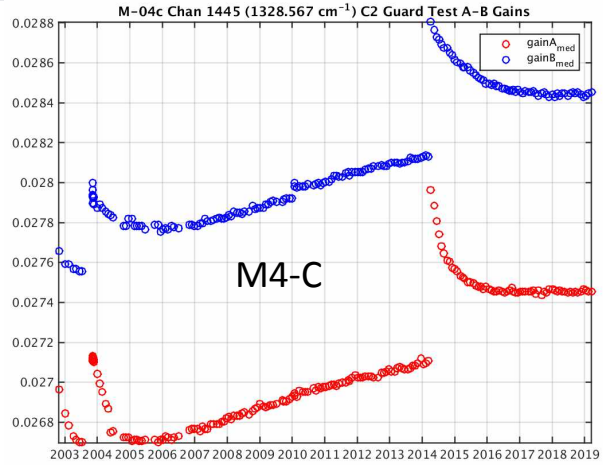
11 Entrance Filters x 12 modules x 2378 detectors

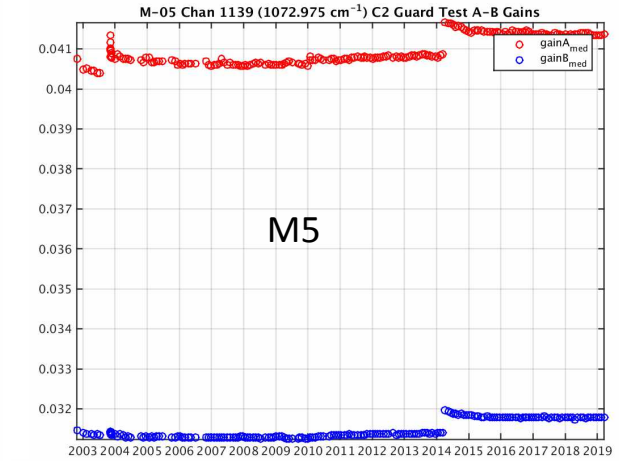


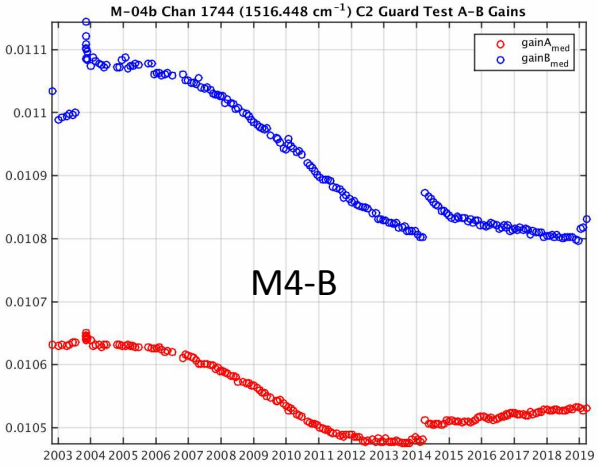
EV +49

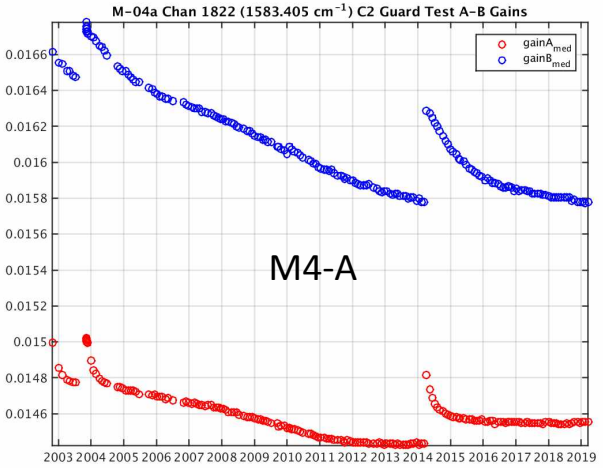
Similar offset/drift seen in radiometric gains

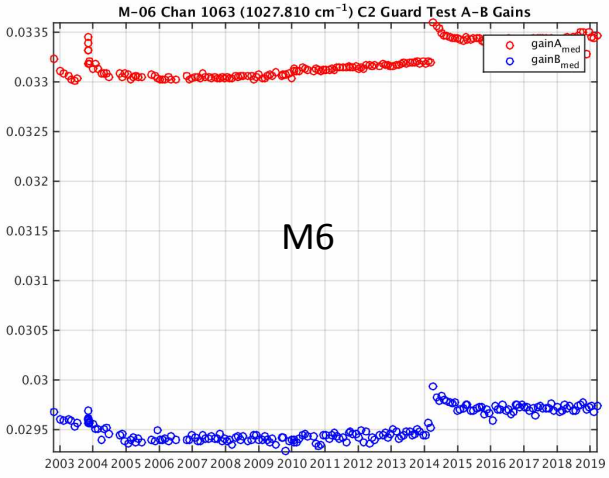




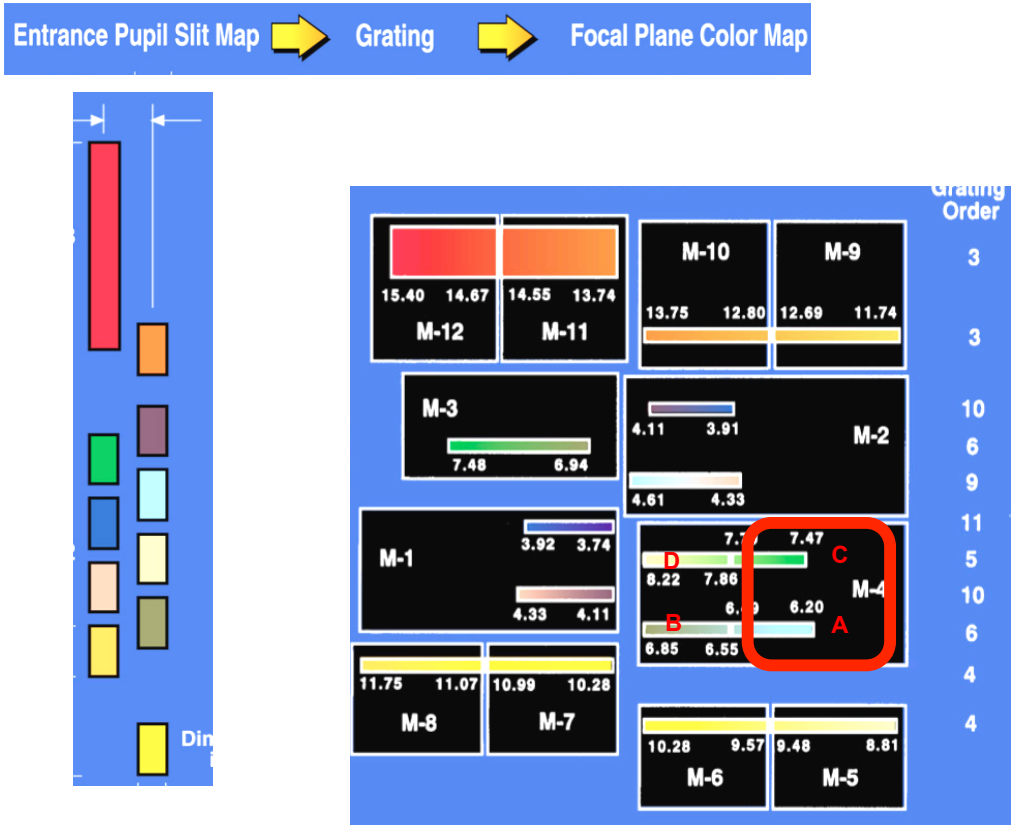








It turns out M4 A&C were mounted on the same substrate



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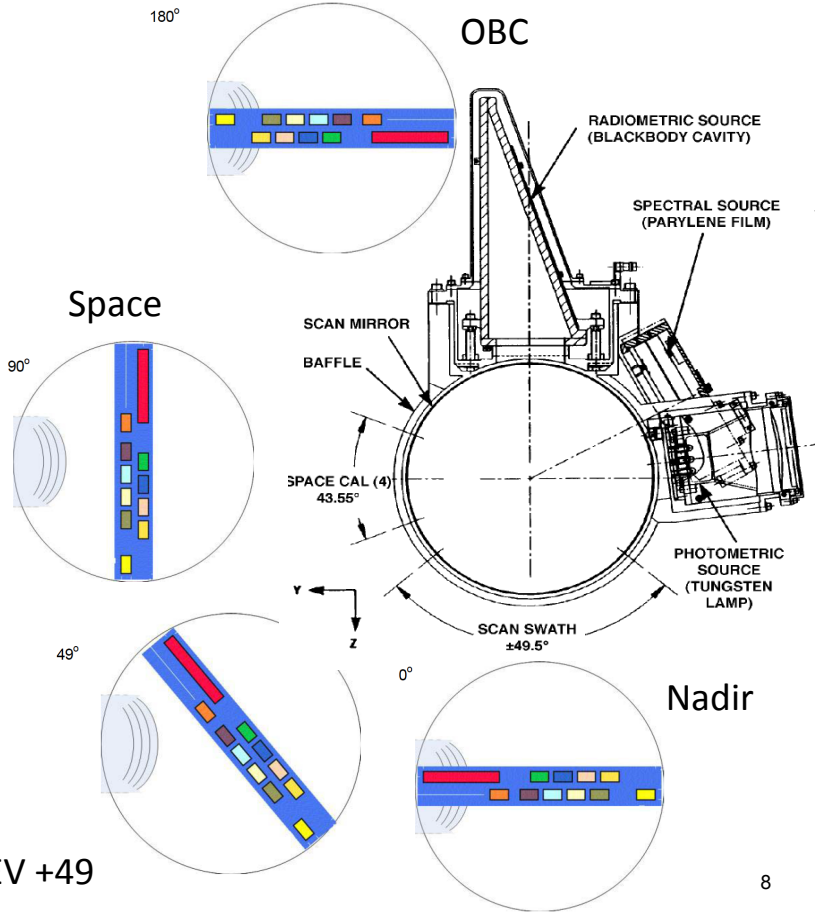
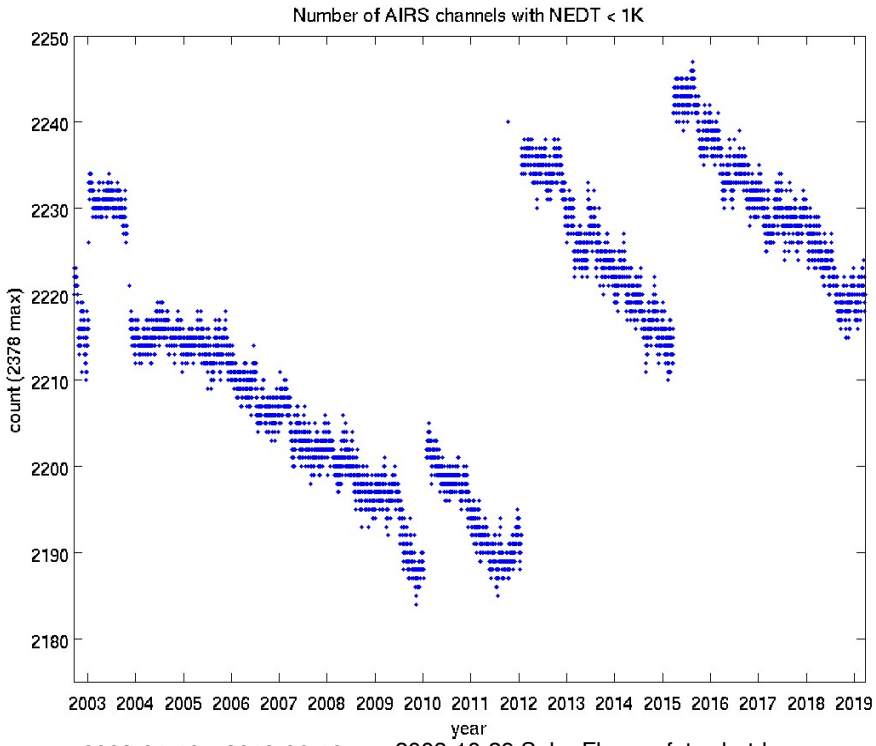


EV +49

AIRS Detector Noise

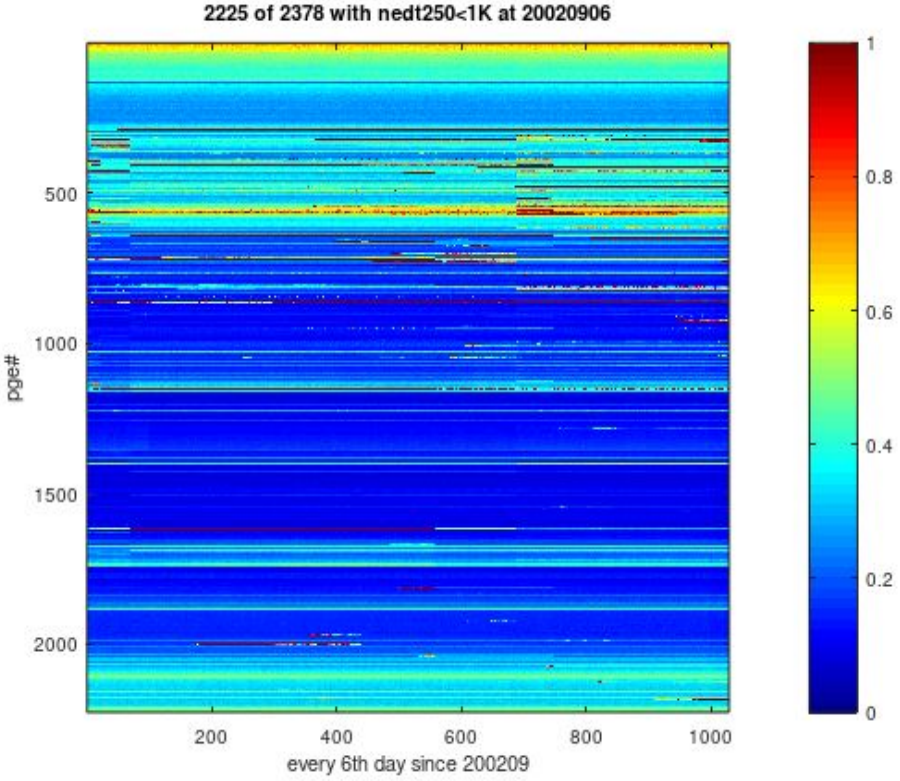
Number of AIRS channels with NEΔT < 1K



2003-01-10 2013-06-10
2003-11-18 2015-03-23
2012-01-21

2003-10-29 Solar Flare safety shutdown
2010-01-09 28V SEU
2014-03-22 Cooler A 58K-> >107K
2016-09-25 Cooler A 58K-> 68K

"image" view of NEDT, channel vs. time



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Level 1C

- Beta version (“v6”)
  - cleans noisy and known bad detectors, fills spectral gaps
  - 2645 frequencies vs. 2378 in L1B
  - Has been available at the GES DISC as a 1 month rolling window
- V6.6: to be released shortly, adds:
  - spectral model from Strow
  - spectral resampling (to fixed grid)
- V7: Potential Improvements include:
  - improved buddy first-pass replacement
  - improved outlier detection
  - estimate of fill value “goodness”
  - better PCA training set from UMBC
  - better scene inhomogeneity (Cij) metrics/handling (PC 100 current, PC 20, MODIS, other?)

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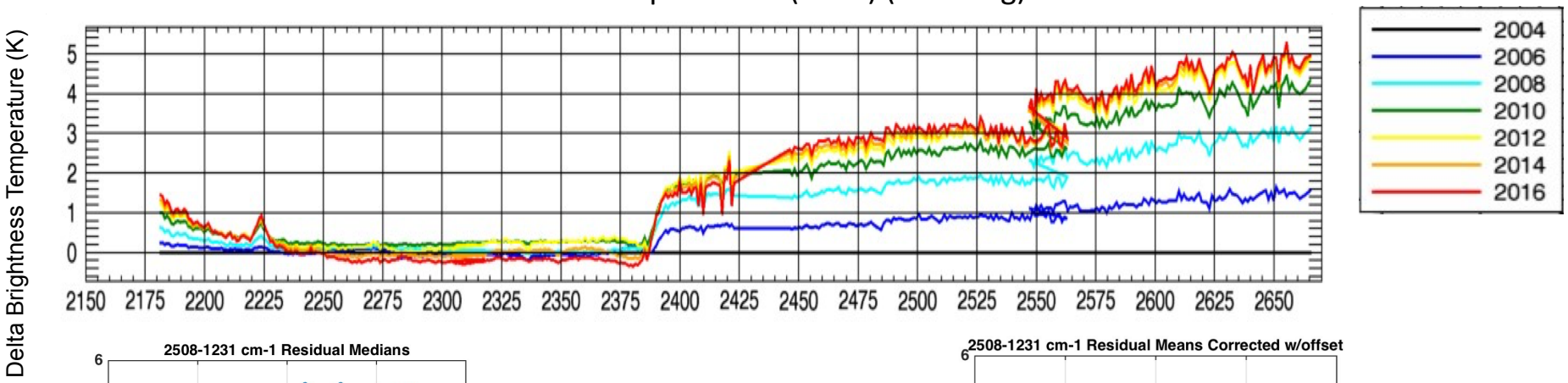
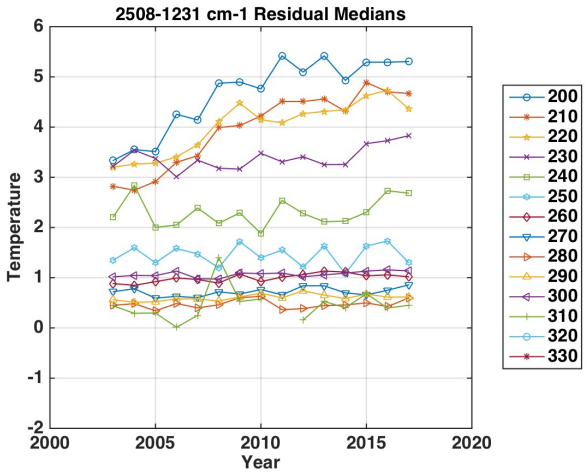
Possible correction for optical contamination induced change in Near Field Response

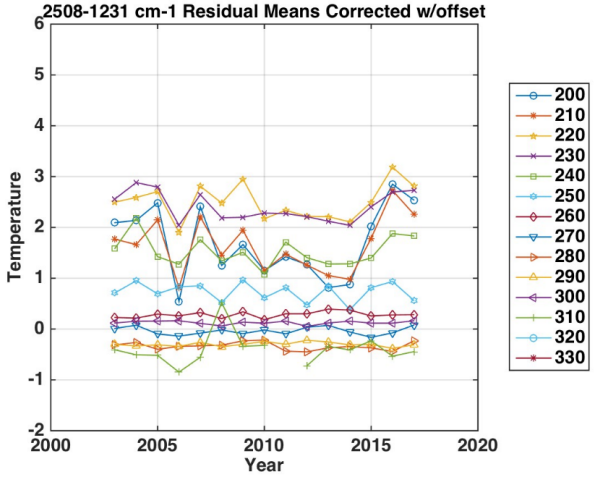
Trend in SW seen at extreme cold temperatures (200K) (Manning)





Trend in 2508-1231 cm-1 before and after correction (Wilson)

Correction not in L1B or L1C.

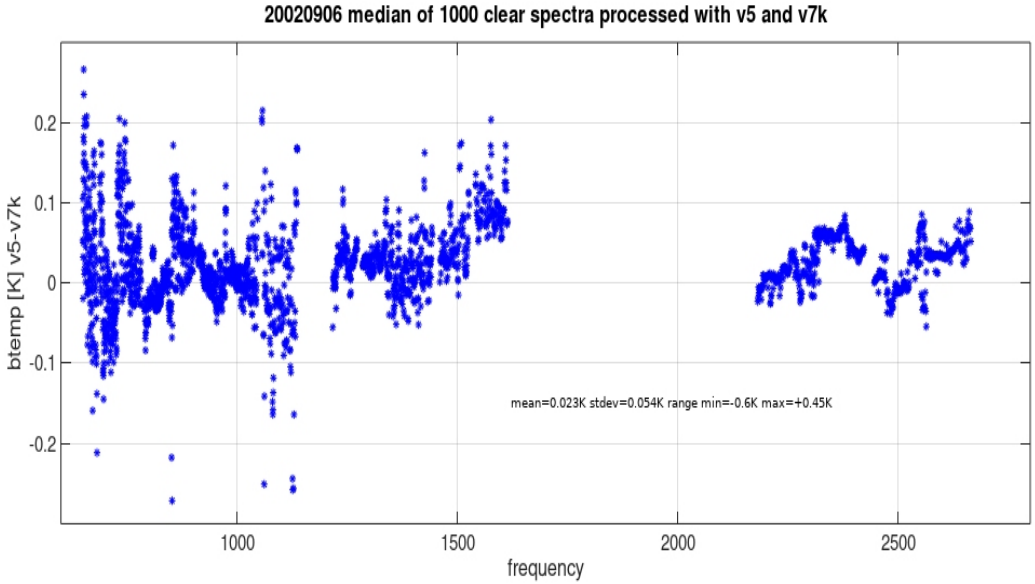


L1B Lien List (Manning version)

Name	V5 worst-case magnitude 200-330 K	V5 worst case magnitude 200 K	V5 worst case magnitude 250 K	V5 worst case magnitude 300 K	L1B/L1C fix?
Cij	> 15 K for a few channels in a very few cases		worst near 250 K from scenes that are half hot & half cold.		v6 L1C rough fix with PCs.
M-08 A/B Cold	0.5 K (up to 1 K for 192 K)	0.5K near 850 cm-1 2004	0.2 K	N/A	L1C empirical fix is possible in future
M-08 A/B Hot	0.15 K	N/A	0.2 K	0.15 K	L1B or L1C recalibration with A vs B EOBC. L1C empirical fix
Other module A/B	0.2 K	0.2 K M-10			L1C empirical fix is possible
SW trend	5 K over 15 years	+5 K over 15 years	+0.3 K over 15 years	Probably less than 0.1 K over 15 years	
Module bounds	0.3 K	0.3 K right minus left M-09 vs M-08	0.03 K right minus left M-01A vs M-02A		v7j will likely fix
M-05/6 trend	0.3 K	+0.3 K	< 0.05 K. Possibly negative.	+0.1 K	v7j will likely fix
shortwave south pole spaceview contamination	0.2 K				Exclude SVs in future L1B. First-order fix in L1C radiometric recal.
M8 A/B fangs	0.2 K	-0.2 K B-A	-0.1 K B-A	-0.06 K B-A	No
M8 FOV 32 bump	0.15 K	+0.15 K B-A	+0.1 K B-A	+0.05 K B-A	No
M5 FOV 38 feature	0.03 K	+0.03 K M5-other	0	-0.02 K M5-other	No

Candidate L1B update

- New coefficient characteristics
  - Physics based improvement of the polarization coefficients (i.e., not based on comparisons to other instruments or earth scene/model references, uses mission long analysis of AIRS space view response
  - Separate A and B side nonlinearity coefficients
  - 4 space views handled differently
  - disparities at module boundaries reduced
  - reduced left/right asymmetry
  - changes < the 0.2K uncertainty
  - these changes are primarily static (bias)
  - there are time dependent t polarization factor, phase terms
  - but do not address majority of time dependent trends seen



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Level 1B PGE implementation changes

- Increase precision of radiances
- Spectral estimate per granule (Bob Deen version)
- Spectral estimate per scan (newer Strow model – new version may need refinements)
- Non-gaussian noise characterization
- Pop/moon detection dynamic thresholds (monthly files vs. 6 minute granules?)
- Clear, SO_2, and dust flags (new algorithms, include in L1B?)
- Scene homogeneity ("C_{ij}") - improve metrics
- Handling of new calibration coefficients (A/B independent, time dependent polarization)
- New output formats (netcdf)

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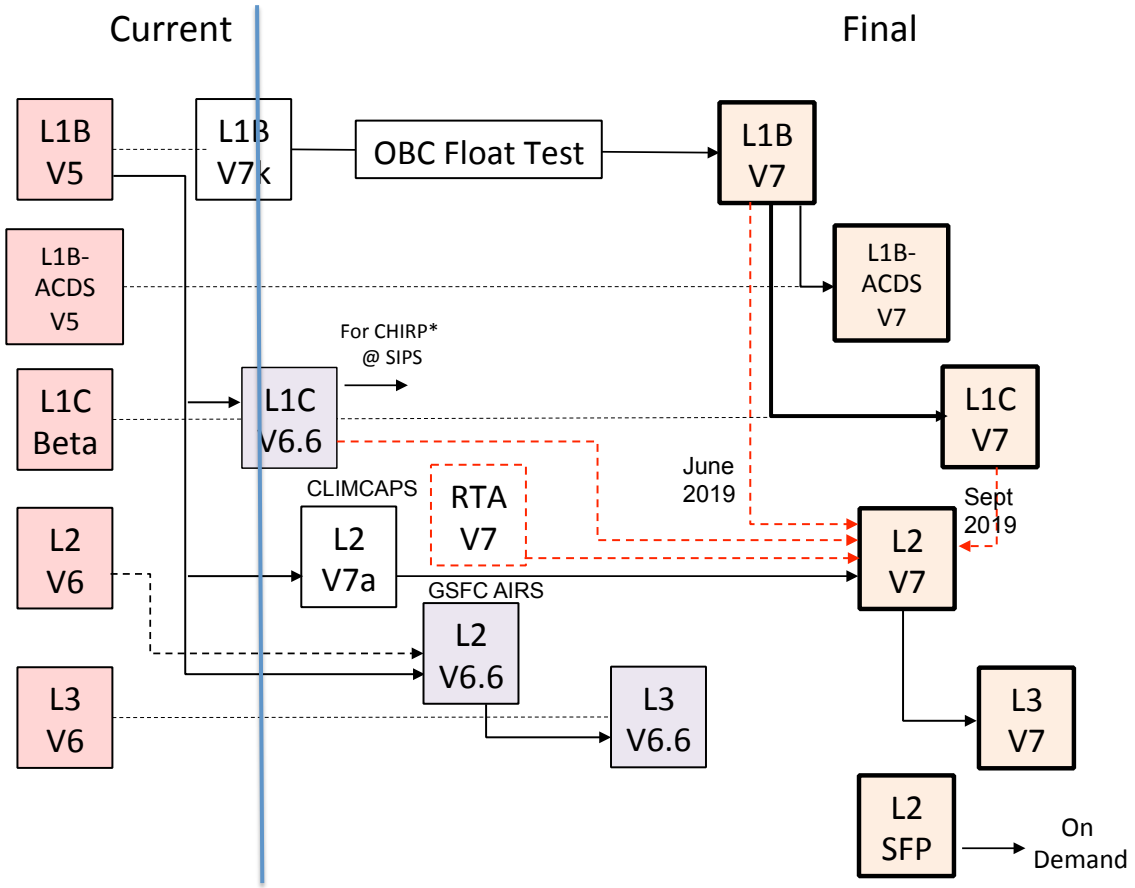
AIRS Product Flow



Layer 1

- Product Delivered Upon Query
- New Test Report
- Full Mission Reprocessed or On-Demand for L2 SFP
- Updated User Guides
- Public Release Announcement

Layer 2

- Separate DAAC Access
- Full Test Report
- Full Mission Reprocessed
- Legacy User Guide Update
- No Public Announcement

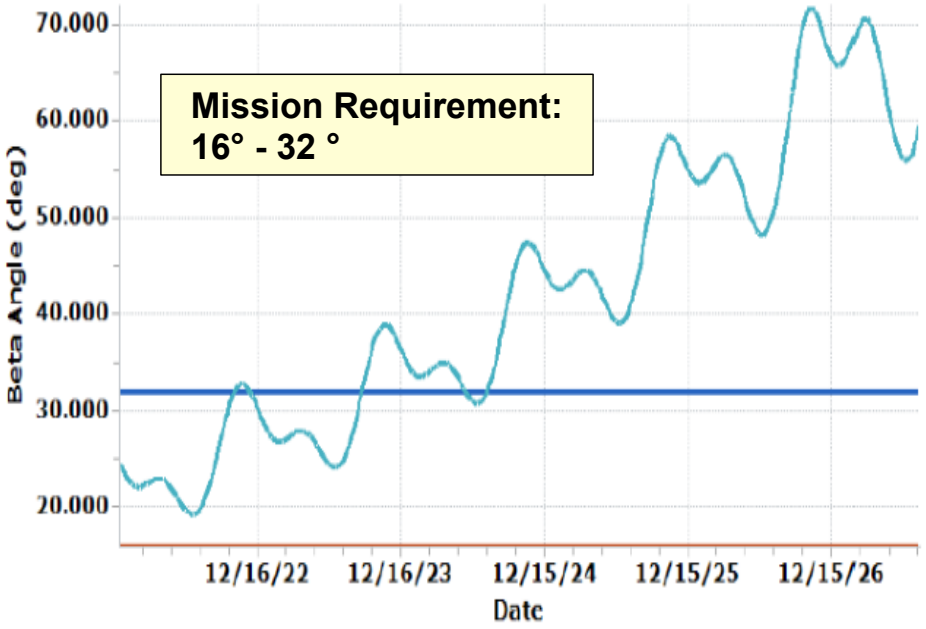
Layer 3

- Separate DAAC Access
- No Add'l Testing or Documents
- Forward Processing Ends Upon V7 Release

Aqua and AIRS Expected to Function Beyond 2022 A-Train Exit

- Post-2022 orbit will have a thermal impact on AIRS – specifically, the 2nd stage heater will need to draw more power to maintain the spectrometer temperature set point
- Safety and thermal/calibration impact being assessed with spacecraft and instrument models
- AIRS has shown no signs of degradation and is expected to last the life of the spacecraft

- A-Train exit (lowering) maneuvers to 680 km: March-May 2022
- Actual fall to earth in mid 2040s



(Charts courtesy of EOS Flight Dynamics Team)

Wrap up

- Radiometric calibration has not been fundamentally changed since launch
- We have a laundry list of known issues
- Our mission:
  - document
  - measure (Special tests: OBC float. A/B independent data? Other?)
  - fix/mitigate if possible
- L1C v6.6 – will add interpolation to a fixed frequency grid – available for the entire mission
- L1B v7 calibration coefficients have been developed
  - Uses a physics based improvement of the coefficients (i.e., not based on comparisons to other instruments or earth scene/model references).
- L1B process improvements (precision, file formats)
- NFR analysis indicates there is potential to address additional time dependent artifacts (not in L1B, but perhaps as a pre-processor to L1C)

- Regarding channel quality, what measures would you find useful?

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